CIRCUIT FOR DRIVING FLAT PANEL DISPLAY

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority benefit of Taiwan application serial no. 92133975, filed on December 03, 2003.

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention generally relates to a circuit of a flat panel display, and more particularly to a circuit for driving a flat panel display.

Description of Related Art

[0002] In the present 21st century information era, interface between users and electronic products, namely, display panels, play significant role in our everyday. Presently, traditional cathode ray tube display (CRT display), is being gradually replaced by a flat display because of its disadvantages of occupying larger space, heavier, high radiation, high power consumption compared to the flat panel displays. Accordingly, because the flat panel display is flatter and thinner occupying less space, lighter, consume less power, and provides high quality display, has become the main stream of the next generation display products. Currently, a FPD is dominated by Liquid Crystal Display (LCD). However, the LCD has several shortcomings, namely, narrow view angle and slow response speed or slow reaction. Accordingly, residual images occur when playing animation pictures. On the other hand, because the liquid crystal itself cannot illuminate and therefore a backlight module is required for

illuminating the LCD display. And further, because the liquid crystals of LCD being colorless, color filters are required. Accordingly, the inclusion of backlight module and the color filters into the LCD display will increase the weight the thickness and the power consumption thereof.

[0003] Organic Luminescence Emitting Diode was disclosed in 1987 and was applied in a FPD so that the need of a backlight module can be eliminated and therefore a thinner and lighter FPD can be achieved. An Organic Luminescence Emitting diode Display, also known as OLED comprises a plurality of organic luminous elements set between two electrodes. When a current is applied to these organic luminous elements via the electrodes, light is emitted. Since the luminance or the brightness of the organic luminescence emitting diode is proportional to applied current, and therefore any current variation will directly affect the uniformity of OLED illumination. Because a general voltage driven pixel cannot compensate illumination non-uniformity among TFT pixels, and therefore it is commonly believed that the current driven pixel provides better illumination uniformity.

[0004] **FIG. 1A** is a circuit diagram illustrating a conventional circuit for driving a flat panel display. **FIG. 1B** is a timing diagram illustrating voltage or current the signals of **FIG. 1A**. As shown in FIG. 1A, a current-driven pixel generally comprises a storage capacitor **131**, which is adapted data to store a voltage. The storage capacitor **131** accumulates the voltage during scanning signal **Scan**. That is, when the scanning signal **Scan** switches from a high voltage level to a low voltage level, the transistors **101** and **103** are turned on, the transistor **102** is turned off, a voltage V_a is stored into the storage capacitor **131** as a data signal **Data**. The voltage V_a is the voltage at node **a** in **FIG. 1A,** which determines the resistance of the transistor **105**. When the scanning

signal **Scan** is cut off (i.e. switching from low to high voltage level), the transistors **101** and **103** are turned off, and the transistor **102** is turned on, the transistor **105** controls the current density flowing through the OLED diode according to the stored voltage V_a. In other words, the stored voltage V_a in the storage capacitor **131** indirectly determines the luminance intensity of OLED diode.

[0005] In practical application, when the scanning signal **Scan** is cut off, the original charge stored at node **a** is affected due to feed-through effect in a manner that the stored voltage V_a is changed as well. When the stored voltage V_a is changed, the current density flowing through the transistor 105 and the organic luminescence emitting diode (OLED) is correspondingly changed. Thus grayscale distortion problem would occur since pixels are of low uniformity. Yet if the capacitance of the storage capacitor Cs is enlarged for intervening feed-through effect, the pixel-opening rate is reduced, large chip area is consumed and the response speed or the reaction speed is lowered. Accordingly, this approach is not desirable.

SUMMARY OF THE INVENTION

[0006] Accordingly, the present invention provides a circuit for driving flat panel display to improve the response speed or the reaction speed.

[0007] According to an embodiment of the present invention, two complementary transistors are adapted for data sampling of storage capacitor in order to reduce feed-through effect to improve current quality. On the other hand, the capacitance of the storage capacitor is reduced so that the flat panel display can be operated at a higher frequency.

[0008] According to another embodiment of the present invention, a circuit for current-driven flat panel display, and a circuit of an OLED display pixel are provided.

[0009] The present invention provides a circuit for driving a current-driven flat panel display. The circuit receives a current data, a first signal and a second signal, and outputs a current driving the OLED display via current output terminal according to the current data. The circuit comprises a storage capacitor, a transmission gate and a current-limiting transistor. The storage capacitor has a first terminal coupled to system voltage and a second terminal of the storage capacitor is coupled to a storage voltage. The transmission gate includes a first N-type transistor and a first P-type transistor. A first source/drain terminal of the first N-type transistor is coupled to a first source/drain terminal of the first P-type transistor to serve as the first input/output terminal of the transmission gate. A second source/drain terminal of the first N-type transistor is coupled to a second source/drain terminal of the P-type transistor to serve as the second input/output terminal of the transmission gate. A gate of the first N-type transistor serves as a first gate terminal of the transmission gate, and a gate of the second N-type transistor serves as a second gate terminal of the transmission gate. The first input/output terminal of the transmission gate is coupled to the storage capacitor, and the second input/output terminal of the transmission gate is coupled to the data current source. The first gate terminal of the transmission gate is coupled to the first signal, and the second gate terminal of the transmission gate is coupled to the second signal. A gate of the current limiting transistor is coupled to the storage voltage, wherein the first source/drain terminal is coupled to the system voltage, the second source/drain terminal is coupled to the current output terminal. The current limiting transistor is for

determining current density flowing through the transistor according to the storage voltage.

[0010] The present invention provides circuit for driving a current-driven flat panel display. The circuit receives a current data, a first signal and a second signal, and outputs a current to the OLED display via driving current output terminal according to a storage voltage. The circuit comprises a storage capacitor, a transmission gate, a current limiting transistor, a second P-type transistor, a third P-type transistor and a fourth P-type transistor. The storage capacitor has a first terminal coupled to the system voltage and a second terminal coupled to the storage voltage. The transmission gate comprises an N-type transistor and a first P-type transistor. A first source/drain of the N-type transistor is coupled to a first source/drain of the first P-type transistor to serve as a first input/output terminal of the transmission gate. A second source/drain of the first P-type transistor is coupled to the second source/drain to serve as a second input/output terminal of the transmission gate. A gate of the N-type transistor serves as a first gate of the transmission gate, and a gate of the first P-type transistor serves as a second gate of the transmission gate. The first input/output terminal of the transmission gate is coupled to the storage voltage, the first gate of the transmission gate is coupled to the first signal, and the second gate of the transmission gate is coupled to the second signal.

[0011] A gate of the current limiting transistor is coupled to the storage voltage. A source/drain terminal of the current limiting transistor is coupled to the system voltage. The current limiting transistor is for limiting current density flowing through the transistor according to the storage voltage. A first source/drain terminal of the second P-type transistor is coupled to the second input/output terminal of the transmission gate

as well as to a second source/drain of the current-limiting transistor. A second source/drain terminal of the second P-type transistor is coupled to the current output terminal. A first source/drain terminal of the third P-type transistor is coupled to the storage voltage, a second source/drain and a gate of the third P-type transistor are both coupled to a gate of the third P-type transistor. A source/drain terminal of the fourth P-type transistor is coupled to the gate of the third P-type transistor, a second source/drain of the fourth P-type transistor is coupled to the data current source, and a gate of the fourth P-type transistor is coupled to the second signal.

[0012] Because the current density flowing through the transistor is controlled by the transmission gate comprised of two complementary transistors, and therefore the feed-through effect is avoided and also a better grayscale performance is achieved via data sampling of the storage capacitor by the transmission gate. Meanwhile, storage capacitor is reduced to achieve higher operation frequency of the pixels. Since storage capacitor is reduced, higher resolution of the current-driven flat panel display is achieved.

[0013] The above is a brief description of some deficiencies in the prior art and advantages of the present invention. Other features, advantages and embodiments of the invention will be apparent to those skilled in the art from the following description, accompanying drawings and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] **FIG. 1A** is a circuit diagram illustrating a conventional circuit for driving a current-driven flat panel display.

[0015] **FIG. 1B** is a timing diagram illustrating voltage or current signals of the current-driven flat panel display shown in **FIG. 1A**.

[0016] **FIG. 2A** is a block diagram illustrating a circuit for driving a current-driven flat panel display according to one embodiment of the present invention.

[0017] **FIG. 2B** is a pixel circuit diagram illustrating an OLED display panel according to one preferred embodiment of the present invention.

[0018] **FIG. 2C** is a timing diagram of voltage or current signals of the OLED display shown in **FIG. 2B**.

[0019] **FIG. 3** is a view of a circuit diagram of an OLED display panel according to one preferred embodiment of the present invention.

[0020] **FIG. 4** is a view of a circuit diagram of an OLED display panel according to another embodiment of the present invention.

[0021] **FIG. 5** is a view of a circuit diagram of an OLED display panel according to yet another embodiment of the present invention.

[0022] **FIG. 6** is a view of a circuit diagram of an OLED display panel according to yet another embodiment of the present invention.

[0023] **FIG. 7** is a view of a circuit diagram of an OLED display panel according to yet another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] This present invention applies to various current-driven flat panel displays. In favor of description for this present invention, an organic luminescence emitting display (OLED) is exemplary. Thus the scope of the present invention is not limited with the following description of the preferred embodiments.

[0025] Referring to **FIG. 2A**, a block diagram of a circuit for driving a current-driven flat panel display according to one preferred embodiment of the present invention is shown. In **FIG. 2A**, circuit of one of the pixels of the OLED display is depicted, which illuminates upon receiving the current outputted from current output terminal **210**. In this preferred embodiment, the OLED in the figure is an organic luminescence emitting diode, for example. In this embodiment of the present invention, two complementary transistors **203** and **204** are used in order to maintain node **a** at a voltage V_a. The two transistors **203** and **204** are complementary transistors, meaning one being N-type transistor **204** and the other being P-type transistor **203**. Two complementary transistors are required to satisfy the two conditions represented by the following equations $\mu_N(W_N/L_N) = \mu_P(W_P/L_P)$ and $W_N \times L_N = W_P \times L_P$, where μ denotes carrier mobility, W denotes channel width of the transistors, and L denotes channel length of the transistors. The first condition renders the current flowing through the P-type transistor **203** and the N-type transistor **204** similar to that flowing through the transmission gate **240**, and the second condition reduces or eliminates feed-through effect of the storing voltage V_a by switching off of the scanning signal **Scan**. Those skilled in the art will appreciate that it is not practical to make the P-type transistor **203** and the N-type transistor **204** completely complementary, however it should be understood that higher the complementation between the P-type transistor **203** and the N-type transistor **204** is, the better the performance of reducing or eliminating the feed-through effect is. Accordingly, even when the foregoing transistors **203** and **204** are not completely complementary; it is still within the scope of the present invention.

[0026] Assuming that the voltage at node **a** in **FIG. 2A** is the storing voltage V_a. When the scanning signal **Scan** is in on state (low level voltage in this preferred embodiment, for example), the P-type transistor **203** is turned on. A complementary-scanning signal **XScan** is inverse of the scanning signal **Scan** in this preferred embodiment, for example; therefore the N-type transistor **204** is also turned on. The storage capacitor **231** is thus charged with the storage voltage V_a during this period. When the scanning signal **Scan** switches off (being high level voltage in this preferred embodiment, for example), the transistor **203** is turned off. Since the complementary-scanning signal **XScan** is inverse of the scanning signal **Scan**, the transistor **204** is also turned off. The storage capacitor **231** provides the storage voltage V_a during this period so that a constant current is sustained between a source and a drain of the current limiting transistor **202**, so that the OLED is illuminated.

[0027] The difference between the application in this present invention as opposed to the prior art is described with reference to another embodiment hereinafter. Referring to **FIG. 2B**, a pixel circuit for driving an OLED display according to another embodiment of the present invention is illustrated. **FIG. 2C** illustrates timing diagrams of the signals of the pixel circuit shown in **FIG. 2B**. Referring to both **FIG. 2B** and **2C**, the circuit comprises two complementary transistors **203** and **204**, which are similar to the aforementioned P-type transistor **203** and the N-type transistor **204** constructing the transmission gate **240**, and therefore detailed description thereof are not repeated hereinafter. When the scanning signal **Scan** switches on (low level voltage in this embodiment, for example), both the P-type transistor **203** and the P-type transistor **201** are turned on, and the N-type transistor **206** is turned off. The complementary-scanning signal **XScan** is inverse of the scanning signal **Scan** in this embodiment, for

example; thus the N-type transistor **204** is also turned on. The storage voltage V_a is hence equal to V_x subtracted from the system voltage VDD, wherein V_x is the voltage difference between the source and the gate of the current limiting transistor **205**. The storage capacitor **231** is charged to a storage voltage V_a during this period. Therefore, a current flowing from system voltage VDD via the current limiting transistor **205** and the transistor **201** to the data current source **Data** is $I_{data}=k(V_x-V_{th})^2$, wherein $k=\mu C_{ox}(W_{205}/L_{205})$, W_{205} and L_{205} are channel width and channel length of the current limiting transistor, respectively.

[0028] When the scanning signal **Scan** switches off (high level voltage in this preferred embodiment, for example), the transistor **203** and the transistor **201** are both turned off, whereas the transistor **206** is turned on. Since the complementary-scanning signal **XScan** is inverse of the scanning signal **Scan**, the transistor **204** is also turned off. The storage capacitor **231** provides a storing voltage V_a so that the current flowing between the drain and the source of the transistor **205** is kept constant, which will in turn correspondingly render the luminance of the OLED diode uniform. When feed-through effect occurs, the transistor **203** changes the storing voltage V_a by ΔV_{203} at node **a** during switching of the scanning signal **Scan**, whereas the transistor **204** changes the storing voltage V_a by ΔV_{204} at node **a**. In this embodiment, transistors **203** and **204** are complementary, for example, thus $\Delta V=\Delta V_{203}+\Delta V_{204}=$ **0**, and therefore the drawbacks of the prior art can be effectively resolved.

[0029] It is to be noted that the circuit for the current-driven flat panel display need not be embodied according aforementioned embodiments described with reference to **FIG. 2A** or **2B** to achieve the purpose of the present invention. The circuit for driving the flat display panel can also be configured according to another embodiment of the

present invention described hereinafter. Referring to **FIG. 3**, shows a circuit diagram of a circuit for driving an OLED display according to yet another embodiment of the present invention is illustrated. As shown in **FIG. 3**, the storage capacitor **331** is coupled to the system voltage VDD via one terminal, and the other terminal of the capacitor **331** is coupled to the storage voltage V_a . The configuration of the P-type transistor **303** and the N-type transistor **304** of the transmission gate **340** are similar to the previous embodiments, and therefore detailed description thereof are not repeated hereinafter. One input/output terminal of the transmission gate **340** is coupled to the storage voltage V_a, and the other input/output terminal of the transmission gate **340** is coupled to a source of the transistor **301** and a gate of the transistor **305**. A gate of the transistor **304** is coupled to a clearing signal **EraseScan**, whereas a gate of the transistor **303** is coupled to a complementary clearing signal **XEraseScan**, wherein the complementary clearing signal **XEraseScan** is inverse of the clearing signal **EraseScan** in this embodiment, for example. A source of the transistor **305** is coupled to the system voltage VDD, and a gate is coupled to the storage voltage V_a. A drain of the transistor **301** is coupled to the data current source **Data**; a gate is coupled to a loading signal **WriteScan**. A gate of the current limiting transistor **307** is coupled to the storing voltage V_a so as to control the flow of current through the source and the drain thereof, wherein the source is coupled to the system VDD and the drain of the current limiting transistor is coupled to the anode of the OLED diode. The cathode of the OLED diode is coupled to a specific voltage level (ground voltage in this embodiment, for example).

[0030] Yet another embodiment of a circuit for driving an OLED display according to the present invention is described with reference to **FIG. 4**. Referring to **FIG. 4**,

another circuit diagram of a circuit for driving the OLED display is illustrated. As shown in **FIG. 4**, the storage capacitor **431** is coupled to the system voltage VDD via one terminal, and the other terminal of the capacitor **431** is coupled to a storing voltage V_a. The configuration of the P-type transistor **403** and the N-type transistor **404** of the transmission gate **440** are similar to previous preferred embodiments, and therefore will not be repeated hereinafter. One input/output terminal of the transmission gate **440** is coupled to the storage voltage V_a, and the other input/output terminal of the transmission gate **440** is coupled to the data current source **Data**. A gate of the transistor **404** of the transmission gate **440** is coupled to the scanning signal **Scan,** a gate of the transistor **403** is coupled to the complementary scanning signal **XScan,** which is inverse of the scanning signal **Scan** in this embodiment of the present invention. A drain and a gate of the transistor **408** are both coupled to the system voltage VDD, whereas a source of the transistor **408** is coupled to a drain of the transistor **402** and a drain of the current limiting transistor **406**. A source of the transistor **402** is coupled to the data current source **Data**, and a gate is coupled to the scanning signal **Scan**. A gate of the current limiting transistor is coupled to the storing voltage V_a, and a source is coupled to the anode of the OLED diode. The cathode of the OLDE diode is coupled to a specific voltage level (ground voltage in this embodiment, for example).

[0031] A circuit for driving an OLED display according to yet another embodiment of the present invention is described with reference to **FIG. 5.** As shown in **FIG. 5,** the circuit diagram is similar to that of **FIG. 2B**. The circuit comprises a first scanning signal **Scan1** corresponding to the scanning signal **Scan** of the previous embodiment,

and a gate of the transistor **507** is coupled to a second scanning signal **Scan2**. With this setup, the OLED is illuminated during charging period of the storage capacitor **531**.

[0032] Referring to **FIG. 6**, a diagram of a circuit for driving an OLED display according to yet another preferred embodiment of the present invention is illustrated. As shown in **FIG. 6**, the storage capacitor **631** is coupled to the system voltage VDD via one terminal, and the other terminal of the storage capacitor **631** is coupled to the storage voltage V_a . The configuration of the P-type transistor **603** and the N-type transistor **604** of the transmission gate **640** are similar to those described in the previous embodiments, and there not repeated hereinafter. One input/output terminal of the transmission gate **640** is coupled to the storage voltage V_a, and the other input/output of the transmission gate **640** is coupled to a source of the transistor **601**, and a drain and a gate of the transistor **607**. A gate of the transistor **603** in the transmission gate **640** is coupled to the scanning signal **Scan**, a gate of the transistor **604** of the transmission gate **640** is coupled to the complementary scanning signal **XScan**, which is inverse of the scanning signal **Scan** in this embodiment, for example. A source of the transistor **607** is coupled to the system voltage VDD. A drain of the transistor **601** is coupled to the data current source **Data**, and a gate is coupled to the scanning signal **Scan**. A gate of the current limiting transistor **605** is coupled to the storage voltage V_a, a source is coupled to the system voltage VDD, and a drain is coupled to the anode of the OLED diode. The cathode of the OLED is coupled to a specific voltage level VSS (ground voltage in this embodiment, for example).

[0033] Referring to **FIG. 7**, a circuit diagram of a circuit for driving an OLED display according to yet another preferred embodiment of the present invention is illustrated. As shown in **FIG. 7**, the storage capacitor **731** is coupled to the system

voltage VDD via one terminal, and the other terminal of the storage capacitor **731** is coupled to the storage voltage V_a. The configuration of the P-type transistor **703** and the N-type transistor **704** in the transmission gate **740** are similar to those described in the previous preferred embodiments, and therefore detailed description thereof is not repeated hereinafter. One input/output terminal of the transmission gate **740** is coupled to the storing voltage V_a, and the other input/output terminal is coupled to a source of the transistor **707** and a drain of the current limiting transistor **705**. A gate of the transistor **703** of the transmission gate **740** is coupled to the scanning signal **Scan,** and a gate of the transistor **704** is coupled to the complementary scanning signal **XScan,** which is inverse of the scanning signal in this embodiment, for example. A gate of the current limiting transistor **705** is coupled to the storage voltage V_a, and a source is coupled to the system voltage VDD. A gate of the transistor **707** is coupled to a source of the transistor **701**, a drain of the transistor **709** and a gate of the transistor **709**. A source of the transistor **709** is coupled to the storing voltage V_a, and a drain of the transistor **707** is coupled to the anode of the OLED diode. The cathode of the OLED diode is coupled to a specific voltage level VSS (ground voltage in this embodiment, for example). A drain of the transistor **701** is coupled to the data current source **Data,** whereas a gate is coupled to the scanning signal **Scan**.

[0034] The above description provides a full and complete description of the preferred embodiments of the present invention. Various modifications, alternate construction, and equivalent may be made by those skilled in the art without changing the scope or spirit of the invention. Accordingly, the above description and illustrations should not be construed as limiting the scope of the invention which is defined by the following claims.